

SNOW AS A HABITAT FOR MICROORGANISMS

Ronald W. Hoham
Department of Biology
Colgate University CS836279
Hamilton, NY 13346

There are three major habitats involving ice and snow, and the microorganisms studied from these habitats are mostly eukaryotic. Sea ice is inhabited by algae called diatoms, glacial ice has sparse populations of green algae called desmids, and the temporary and permanent snows in mountainous regions and high latitudes are inhabited mostly by green algal flagellates. It is the latter habitat that I study and that will be emphasized here. Light is an important factor regulating the distribution of individual species of these algal flagellates. In response to high-intensity light, snow algal cells may produce yellow, orange or red secondary carotenoid pigments. Thus snowfields containing these algae may appear red (open exposure), yellow to orange (partial shading) or green (maximum shading). Red snow is easily seen, but orange and green snows are more difficult to locate and can be easily overlooked in the snowpacks. Several groups of algae are known from snow, and dominant species worldwide belong to the photosynthetic green algal flagellates, *Chloromonas* and *Chlamydomonas*. Other groups include heterotrophic euglenoids and photoauxotrophic golden algae. Life cycles of green algal flagellates are short-lived, complex and governed by light, nutrients, temperature and snowmelt. Active growth occurs during spring and summer when air temperatures remain above freezing for several days. This allows for liquid water to surround snow crystals in snowbanks that are 0.2–1.5 m deep. Light penetrates through the snow germinating the resting spores that lie beneath the snowpack. Resting spores release flagellate cells that swim in the liquid water surrounding the snow crystals at 0° C and migrate towards the surface of the snowpack. Nutrition for growth is derived from the soil at the time of germination, from nutrients released from snow crystals, and from debris and dust from the snowbank surface. The rapid utilization of nutrients by the algae forces the life cycle into the production of resistant resting spores before the snow melts. Resting spores formed through sexual and asexual processes may withstand long periods of desiccation, varying air temperature, and (or) high levels of irradiation after the snow is gone.

A culture collection of approximately 100 strains of snow algae is being maintained at Colgate University. Using defined media, species of snow algae studied axenically in the laboratory indicate that nutrients, pH, temperature, light and alleopathic effects from conifers may influence their growth. Species of snow algae studied in the laboratory may utilize either inorganic or organic sources of phosphorus and nitrogen for their growth. In the Adirondack Mountains, New York, green snow was not discovered until the early 1970's. This is interesting because these algae have been overlooked for two centuries in a region where there are many naturalists and amateur botanists. We are still discovering microorganisms on this planet, and only recently we have found two new groups of prokaryotes, the chloroxybacteria or prochlorons (1975) and *Heliobacterium* (1983). Thus we should not give up our inquiries into the possibility of life on the planet Mars when we have evidence of still finding new organisms on planet Earth. In the Adirondacks, acid precipitation may be selecting for acidic strains of snow algae that grow optimally at pH 4.0–5.0. Populations of *Chloromonas* affect snow chemistry through metabolic processes, and red snow caused by the green alga, *Chlamydomonas nivalis*, accumulates trace metals many hundreds to thousands of times greater in the cells than what is found in the surrounding snow. The snow alga, *Chloromonas*

pichincae, grows optimally at temperatures near freezing (1–4° C), and warmer temperatures (10° C) may alter cell morphology and cause death of these cells. One species of *Chlainomonas* loses its flagella at temperatures above 4° C as observed using a cooling stage. Most species of snow algae develop lipids in response to subfreezing temperatures, but some lyse under these conditions. The snow alga, *Raphidonema nivale*, grows optimally over a wide temperature range from 1–15° C, and other species of snow algae grow best at more mesophilic temperatures. Higher light intensity causes cells of *Raphidonema nivale* to divide more frequently, and cells are more elongate when grown under low light intensity. One species of the flagellate, *Chloromonas*, grows optimally in shaded snowbanks several centimeters beneath the surface receiving about one-thirtieth incident irradiation. Conifers, which grow near snowbanks containing algae, may stimulate or inhibit algal growth through the release of chemical compounds into the snow. In summary, some species of snow algae grow under extreme conditions of cold temperature (0° C), high levels of irradiation, and/or high acidity (optimizing at pH levels near 4.0).

In the snow ecosystem, other organisms encountered besides algae include bacteria, fungi, lichen pieces, protozoa, rotifers and other invertebrates. Most of these organisms have not been studied critically, and little is understood concerning the interactions between them or with the algae. Encapsulated bacteria have been found in the cell walls of the snow alga, *Chlamydomonas nivalis*. It is not known how these bacteria grow in snow or whether there is a symbiosis between the two organisms. Hyphomycetous fungi are known from surface snow; their development is not clear, and it is not known if they exchange nutrients passively with snow algae. The snow fungus, *Phacidium*, grows through melting snow, and algae may passively adhere to the surfaces of the fungal hyphae. When the snow melts, strands of dried fungi with adhering algae may be distributed elsewhere by wind. Several species of protozoa and rotifers are primary consumers of snow algae selecting green colored cells over those that are orange or red. In melting snowbanks, these consumers are usually found in small surface depressions saturated with liquid water. Detritus eaters in the snow include species of waterbears and nematodes. Other species of animals may include snowworms, insects and arachnids.

In conclusion, it is not likely that the eukaryotic snow algae presented here are candidates for life on the planet Mars. Evolutionarily, eukaryotic cells as we know them on Earth may not have had the opportunity to evolve on Mars (if life evolved at all on Mars) since eukaryotes did not appear on Earth until almost two billion years after the first prokaryotic organisms. However, the snow/ice ecosystems on Earth present themselves as extreme habitats where there is evidence of prokaryotic life (eubacteria and cyanobacteria) of which we know literally nothing. Is it possible that some form of life may be locked up in the ice water near the polar regions of Mars? Any future surveillances of extant and/or extinct life on Mars should include probes (if not landing sites) to investigate sites of concentrations of ice water (?liquid water). The possibility of signs of life in Martian polar regions should not be overlooked.